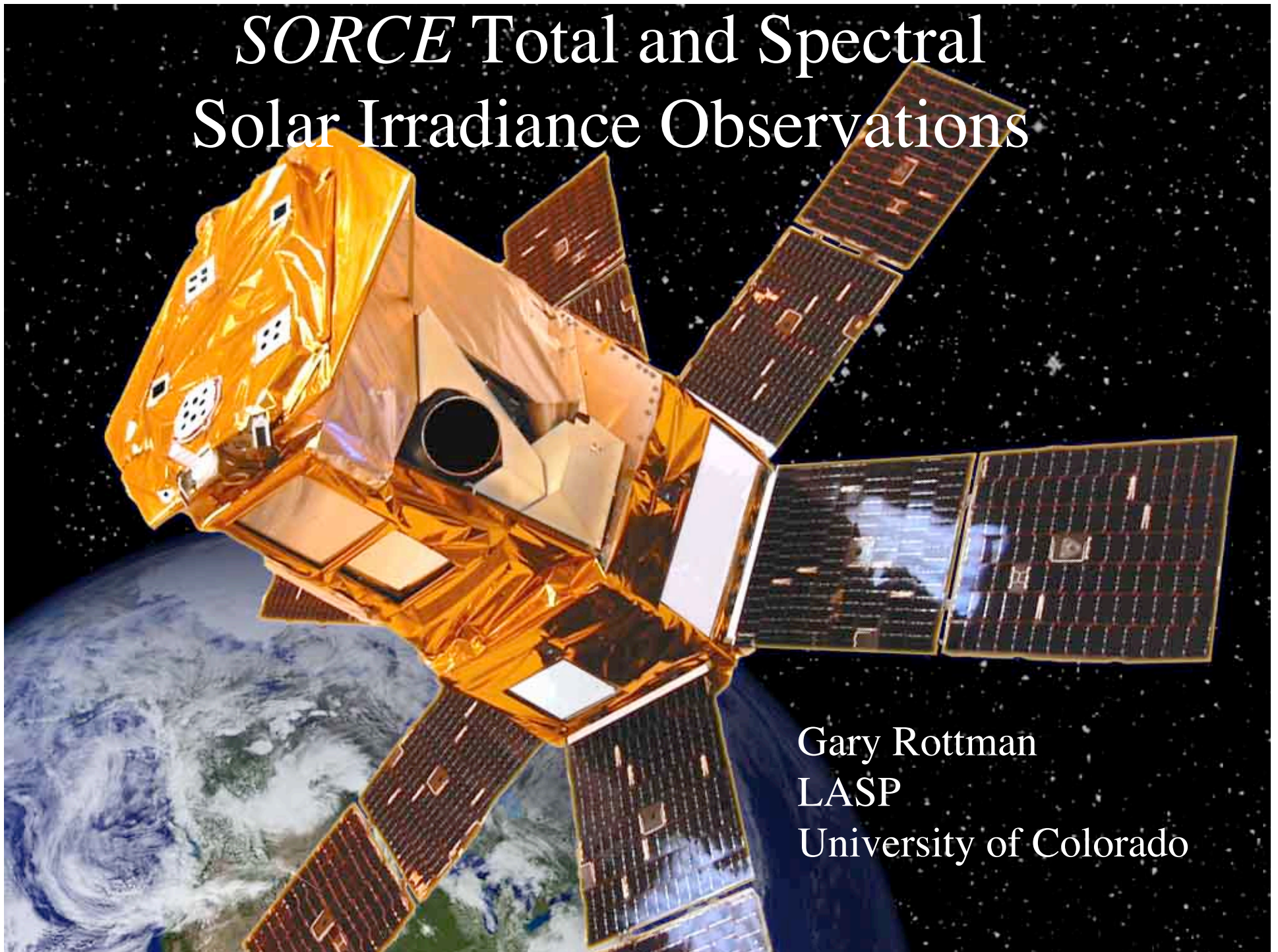


SORCE Total and Spectral Solar Irradiance Observations



Gary Rottman
LASP
University of Colorado

The *SORCE* Mission

The *SORCE* mission is one element of NASA's Earth Science Enterprise. *SORCE* is dedicated to the measurement of solar irradiance — both total and spectral irradiance.

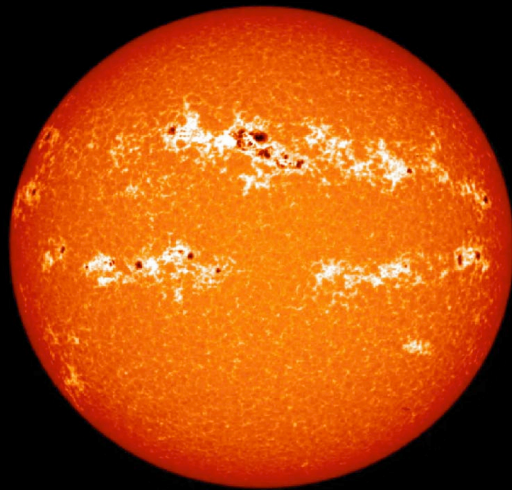
- The *SORCE* has four solar irradiance instruments designed and built at LASP.
- The *SORCE* spacecraft was developed by Orbital Sciences Corporation.
- The *SORCE* was launched on a Pegasus XL rocket on January 25, 2003, and is in a 40° inclination orbit at an altitude of 620 km.
- The *SORCE* is operated from a control center at LASP.



Postcards from *SORCE*



Observation of Climate State Variables

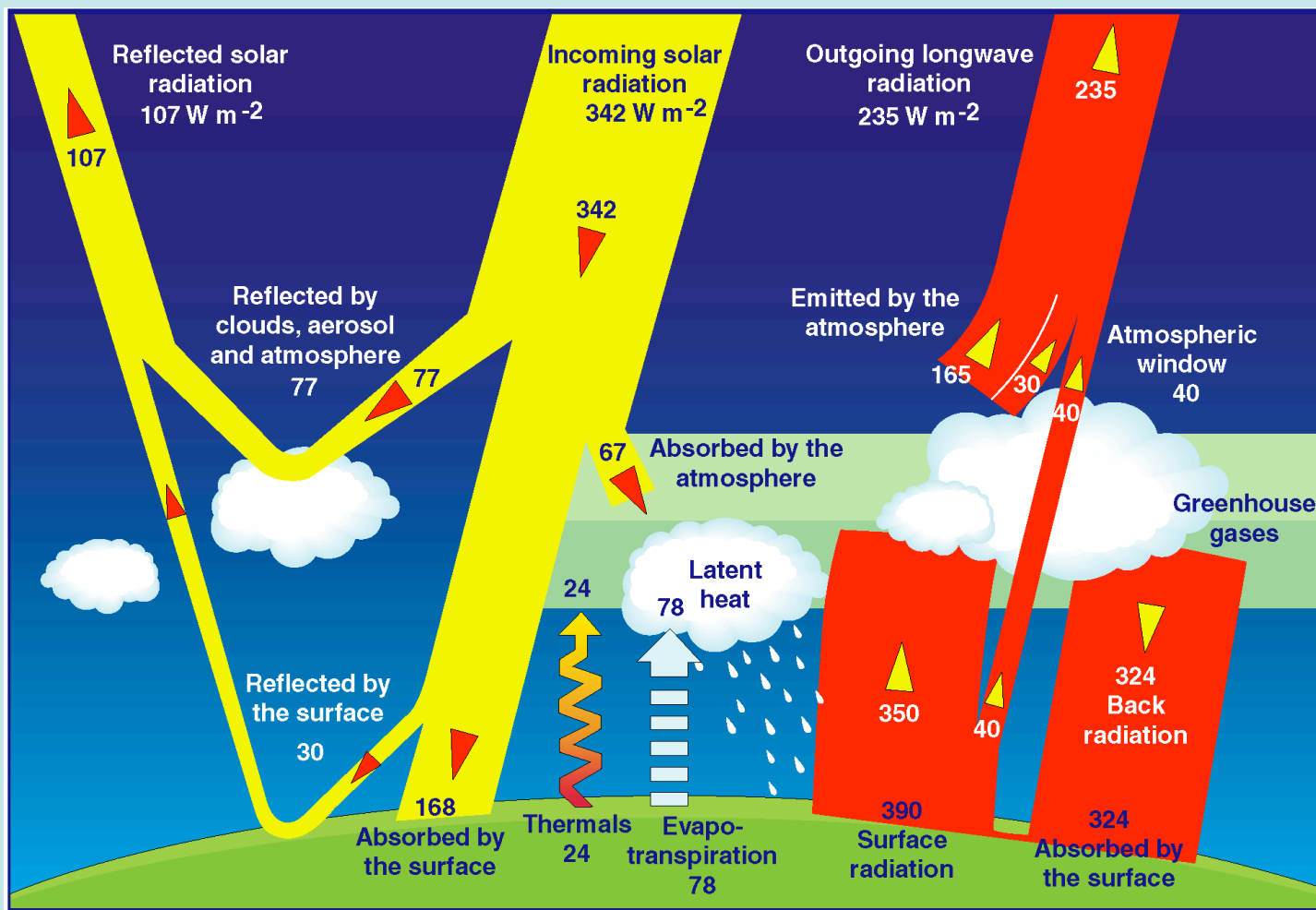


- Total Solar Irradiance
- Spectral Solar Irradiance
- Particles and fields



- Clouds
- Water
- Greenhouse gases
- Shortwave and Longwave surface radiation
- Snow/Ice Cover
- SST and SAT
- Ocean Salinity
- Ocean Topography
- Soil Moisture
- Coastal Zones and Margins
- Vegetation
- + many others

The Earth's Radiation and Energy Balance



Radiation Balance of the Earth (Jeffrey T. Kiehl)

Basic Radiometric Measurements

The *total irradiance* or *radiant flux density* is the radiant flux across a surface element, dA :

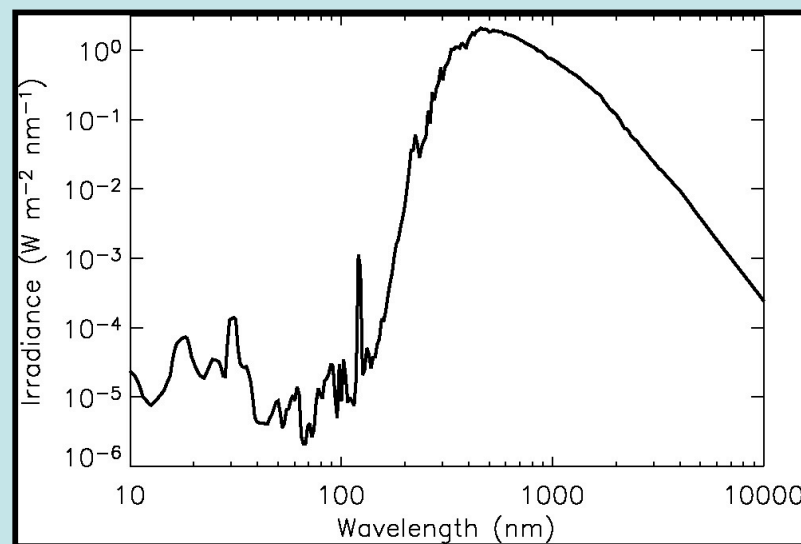
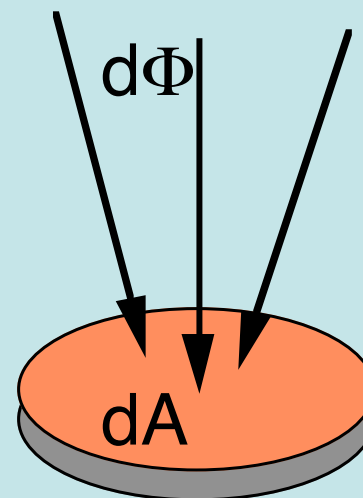
$$E = \frac{d\Phi}{dA} \quad \{W / m^2\}$$

The *spectral irradiance*, E_λ , is the radiant flux density per unit wavelength interval:

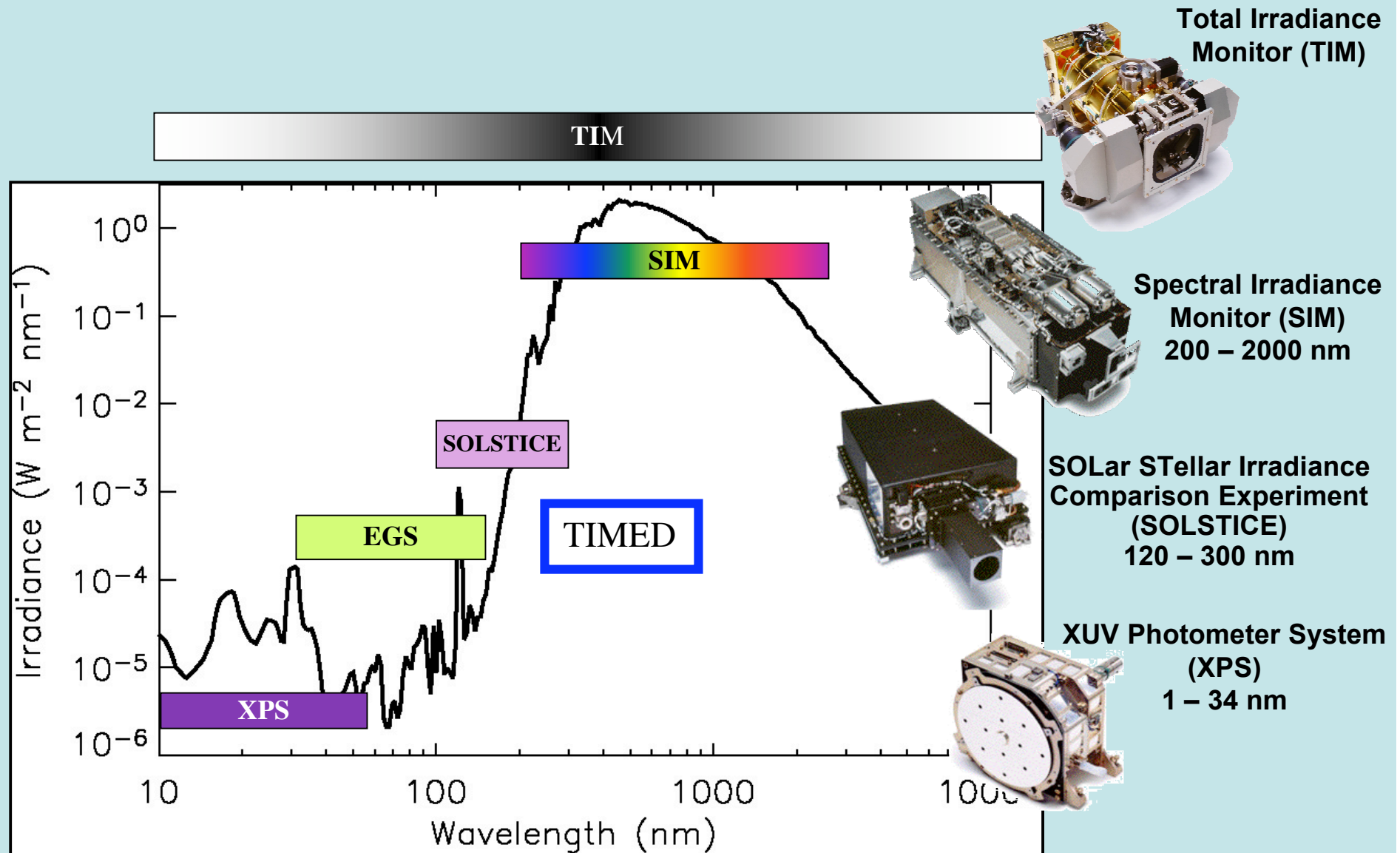
$$E_\lambda = \frac{d^2\Phi}{dA d\lambda} \quad \{W / m^3\}$$

NOTE: the *Total Solar Irradiance*, TSI , is the integral over all wavelengths of the Solar Spectral Irradiance.

$$E = \int_{\lambda=0}^{\infty} E_\lambda d\lambda$$

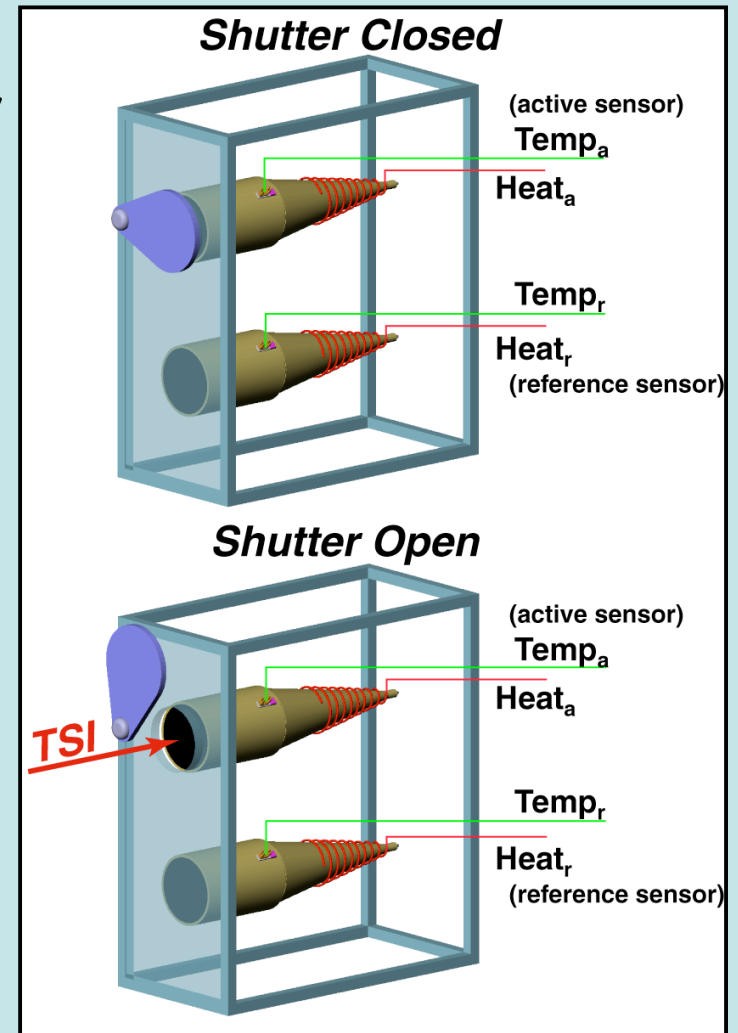


SORCE Instruments



Concept of Electrical Substitution Radiometers

- Based on the measurement of heat flux. Two identical sensors, one **active** and the other used as a **reference**, are connected so that they are in the same thermal environment.
- Joule heat is supplied to each sensor by an "actively controlled" heater circuit so that they attain the same temperature.
- These sensors have high **absorptance** in order to efficiently collect radiation. Photon energy is **completely** converted to heat.
- A shutter opens and solar radiation is allowed to fall on the active sensor — a corresponding amount of Joule heat must therefore be removed from the active sensor in order to maintain the heat flux balance. The change of Joule heat to the active sensor is **equivalent** to the amount of radiation now incident upon it.

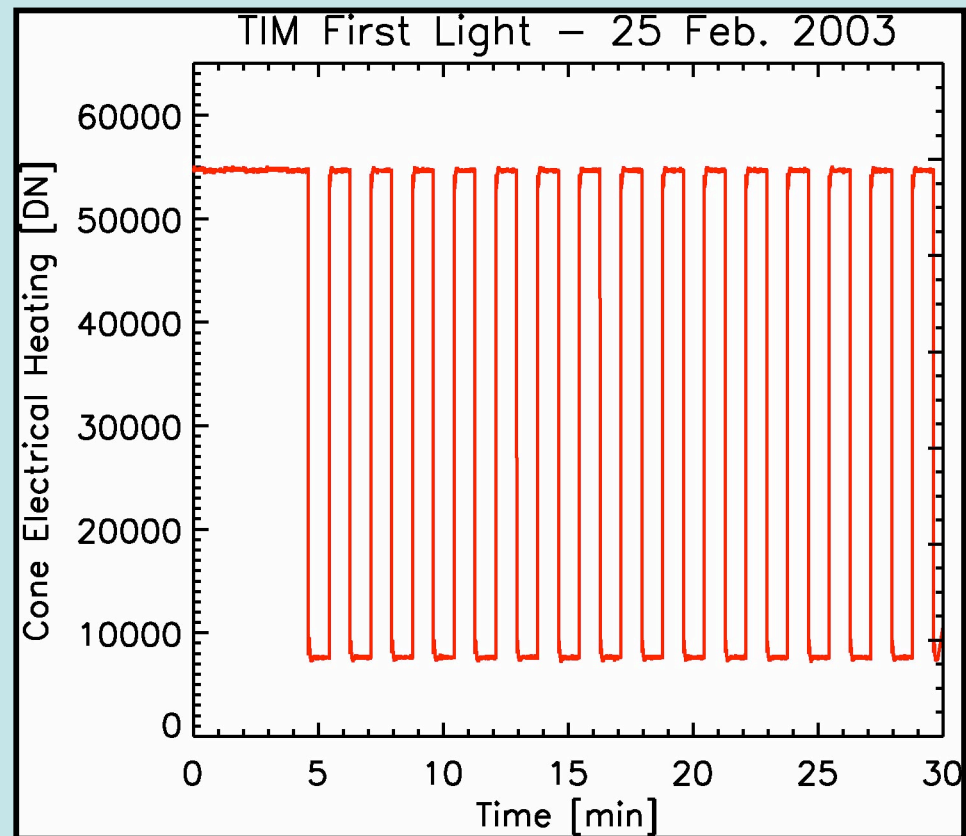


Major Improvement of the TIM ESR

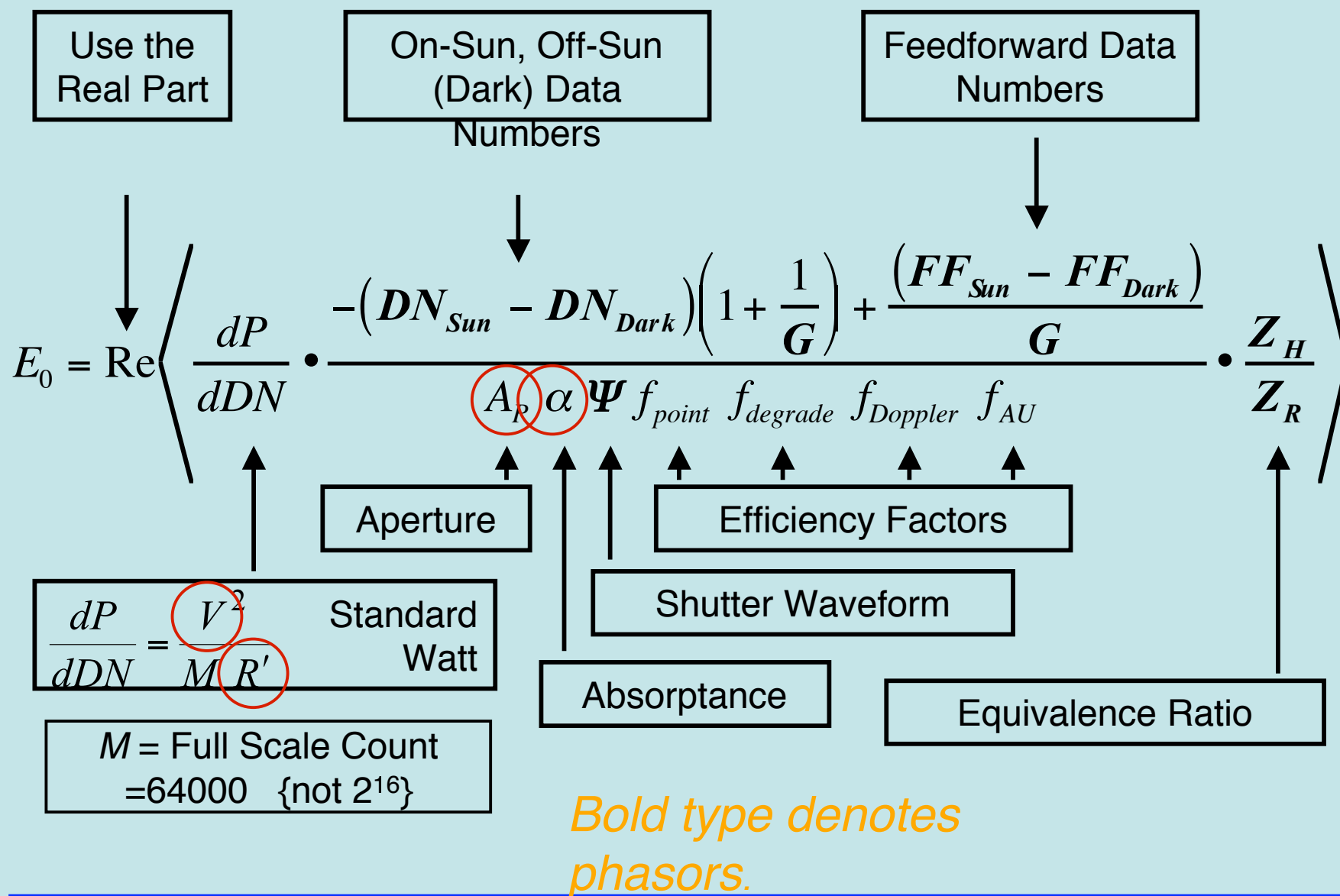


Major

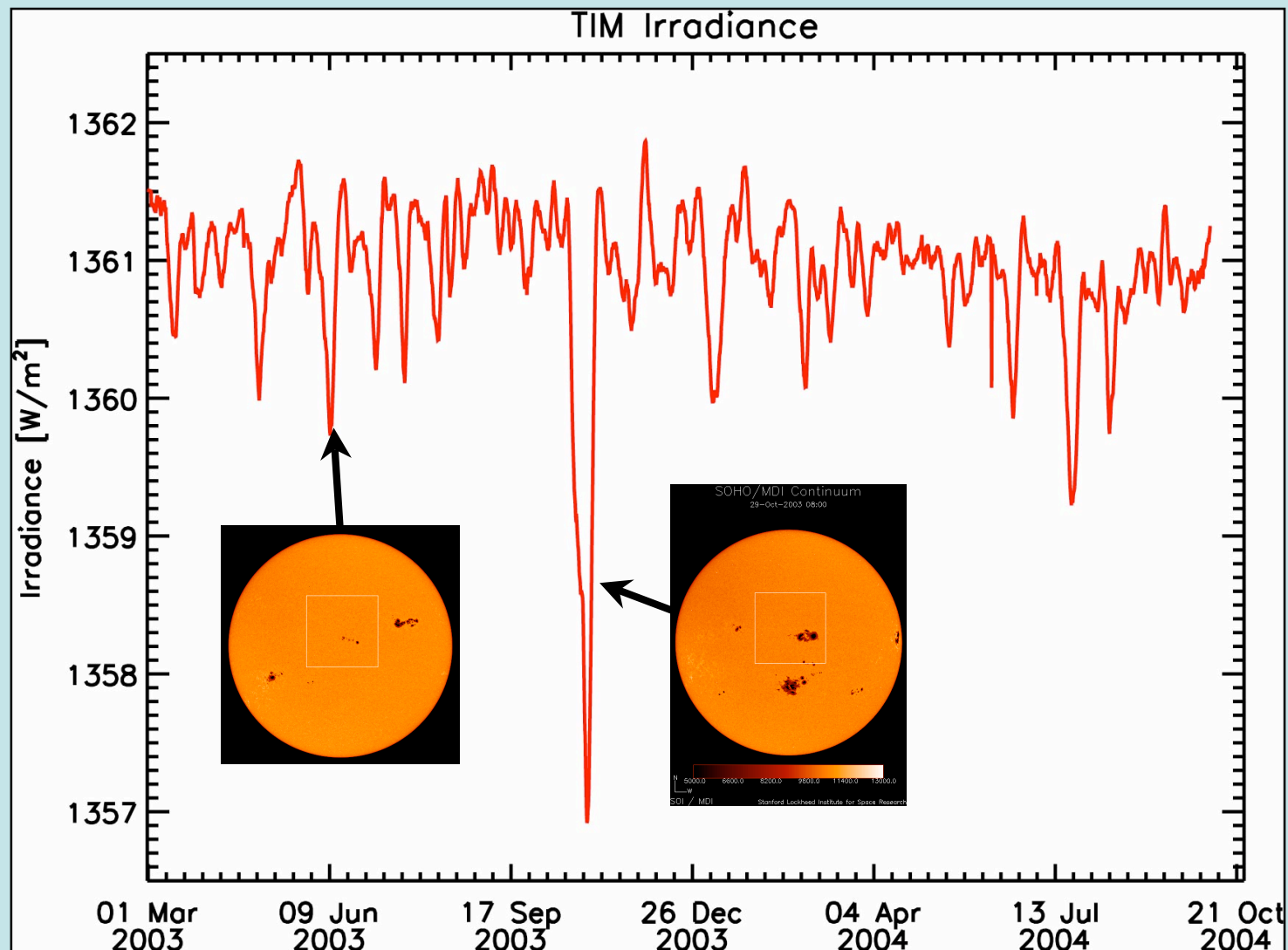
- Phase sensitive detection at the shutter fundamental frequency
- Pulse width modulation of the heater power
- Use of Nickel-Phosphide, NiP, black absorber



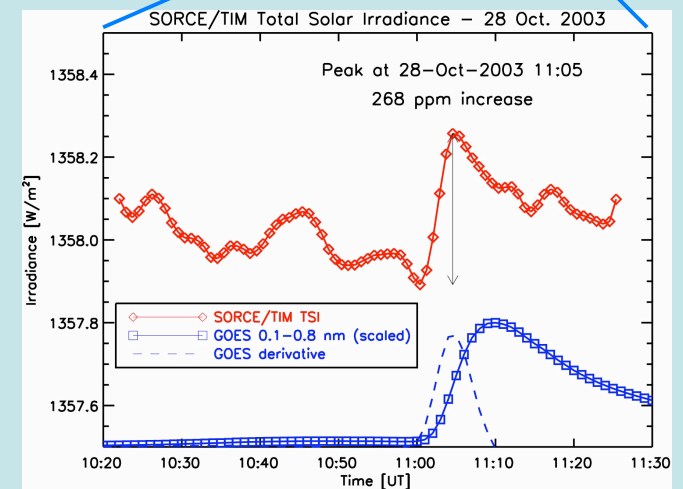
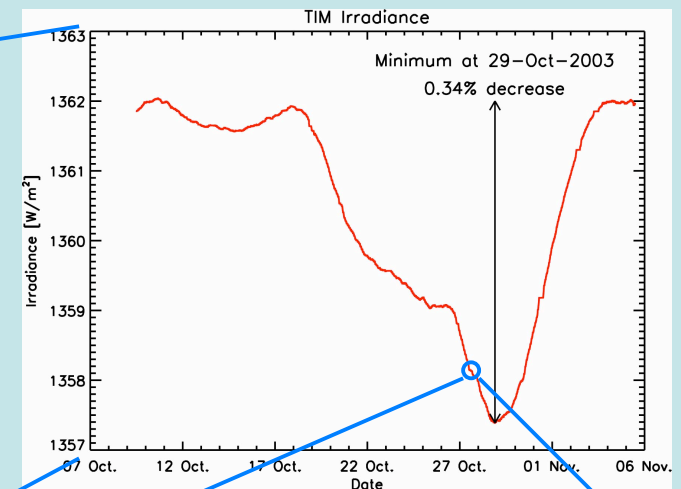
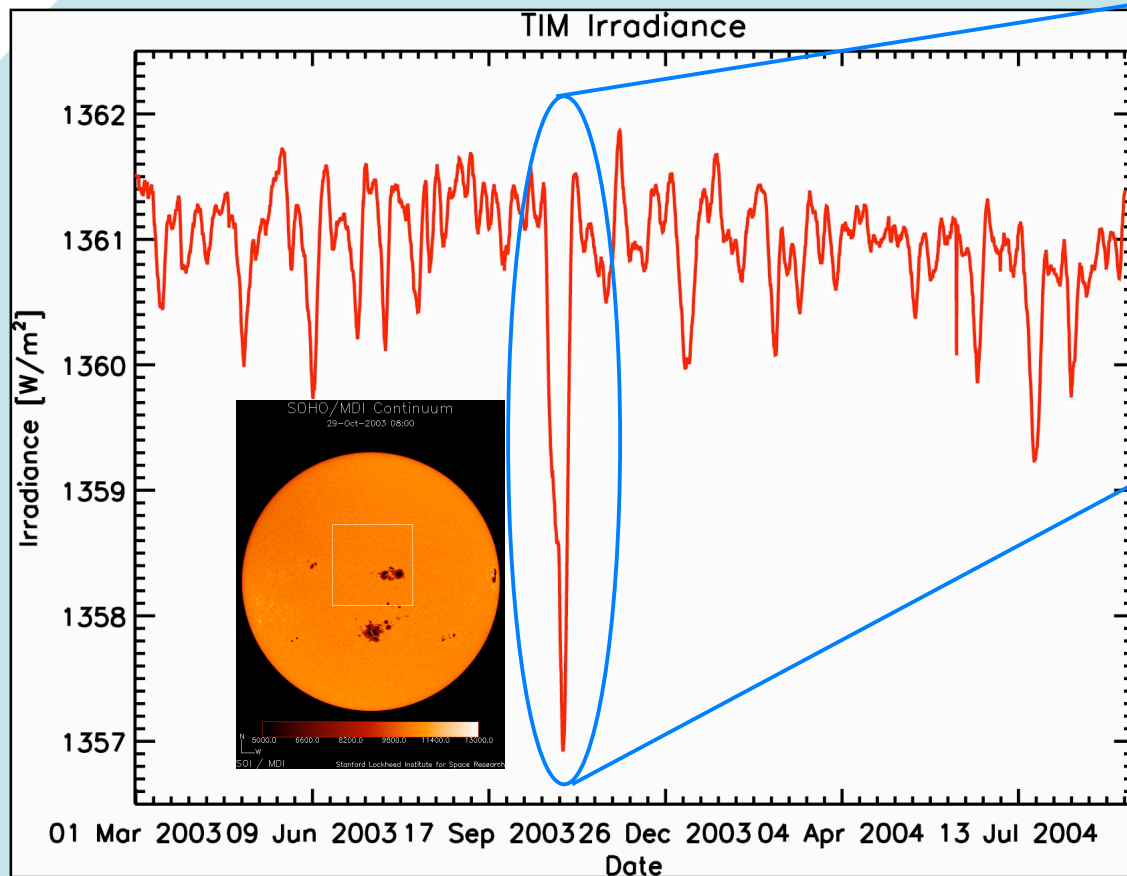
TIM Measurement Equation



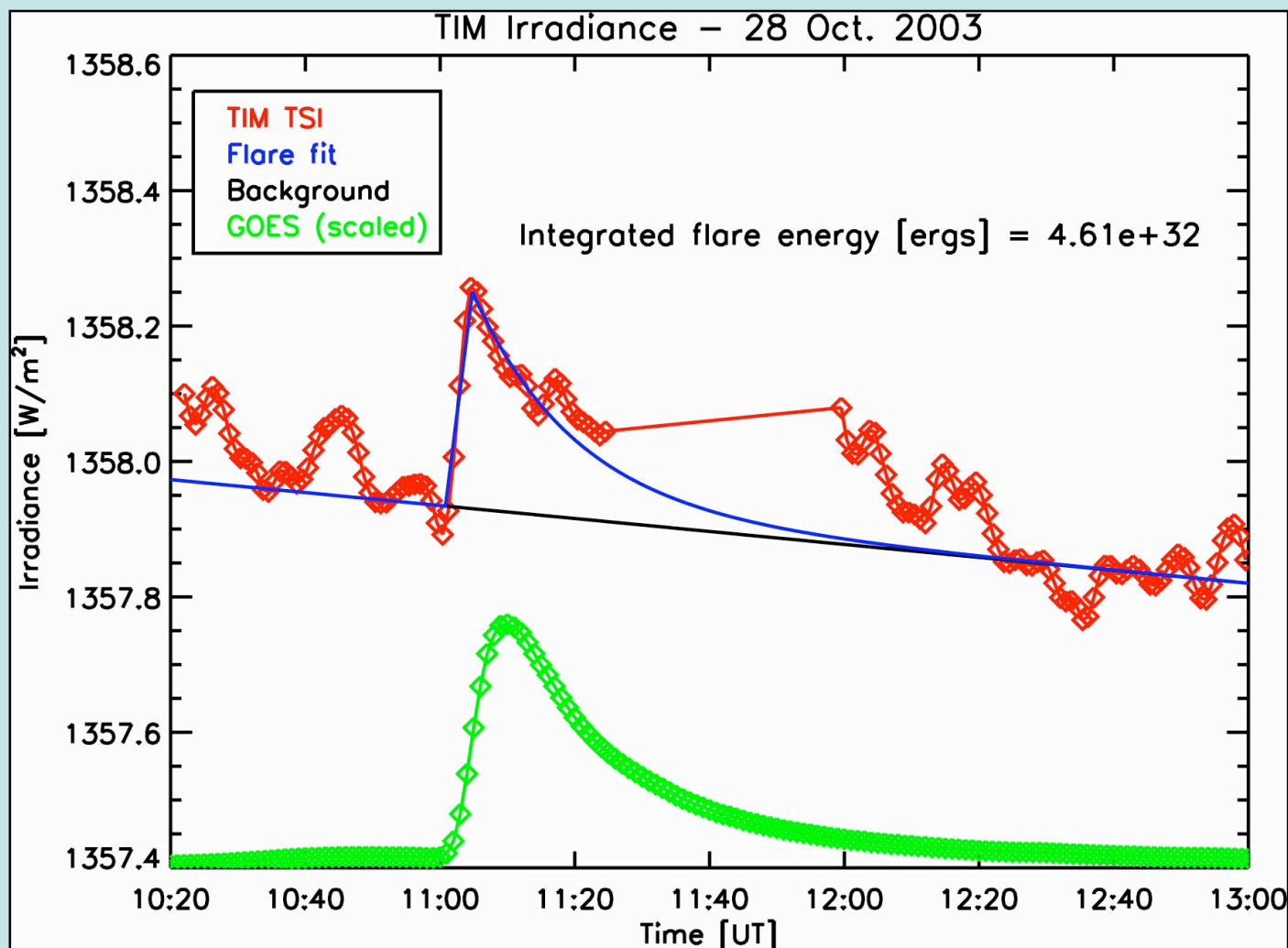
TIM TSI Record



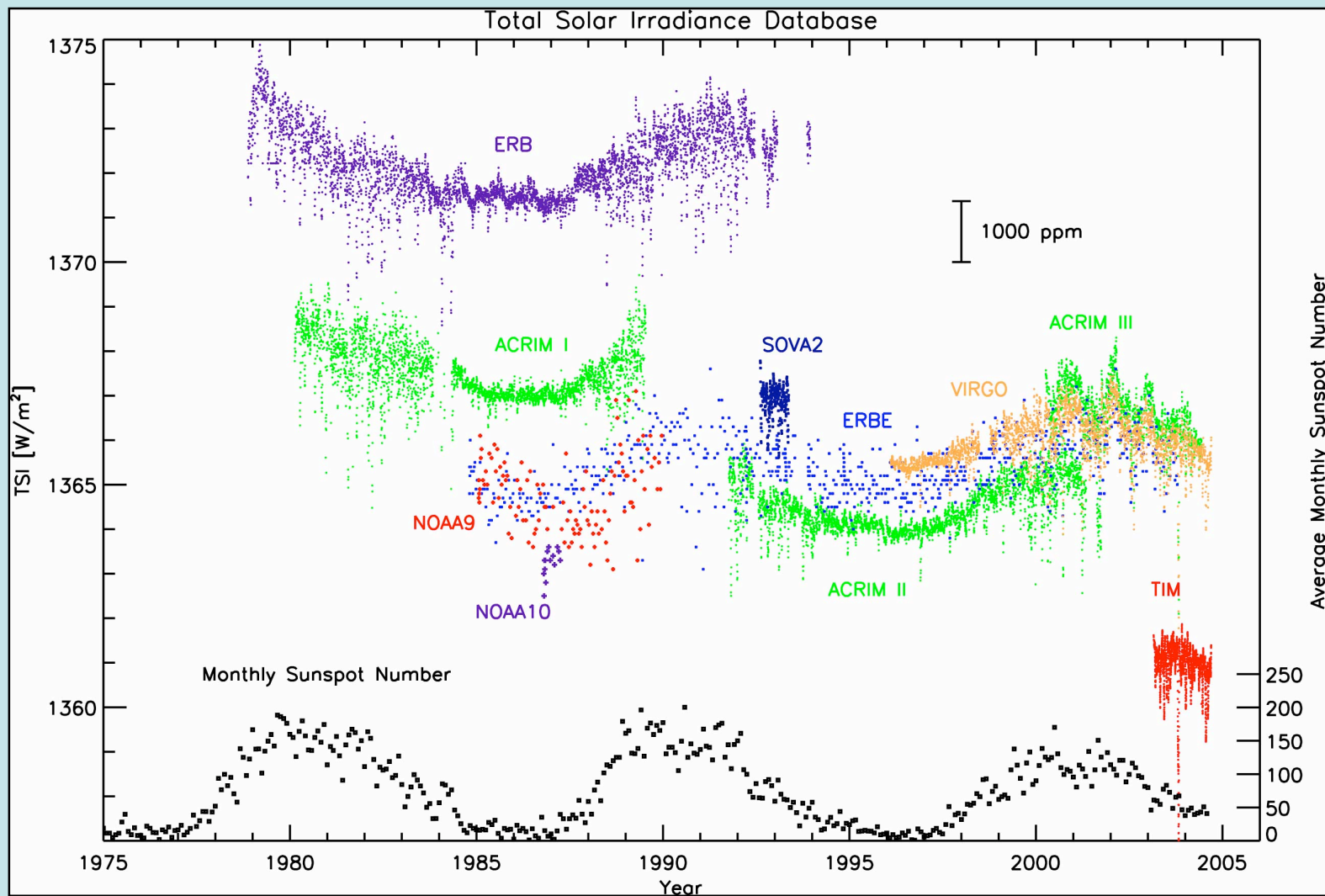
The TIM Measurements Are Very Precise



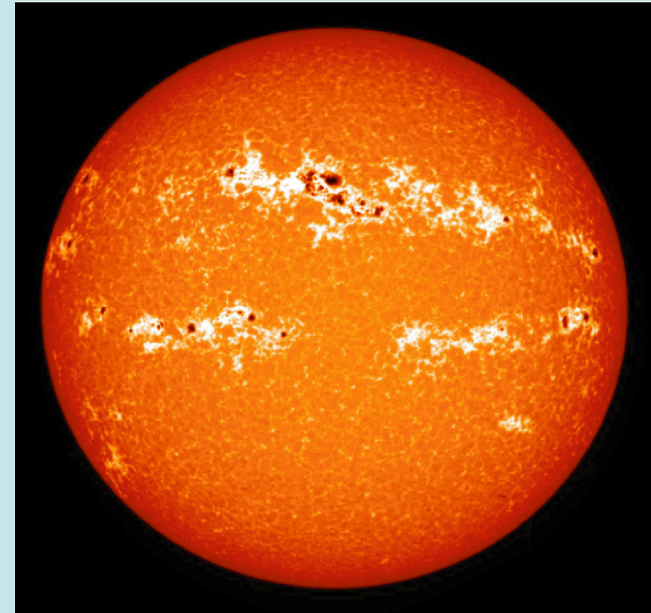
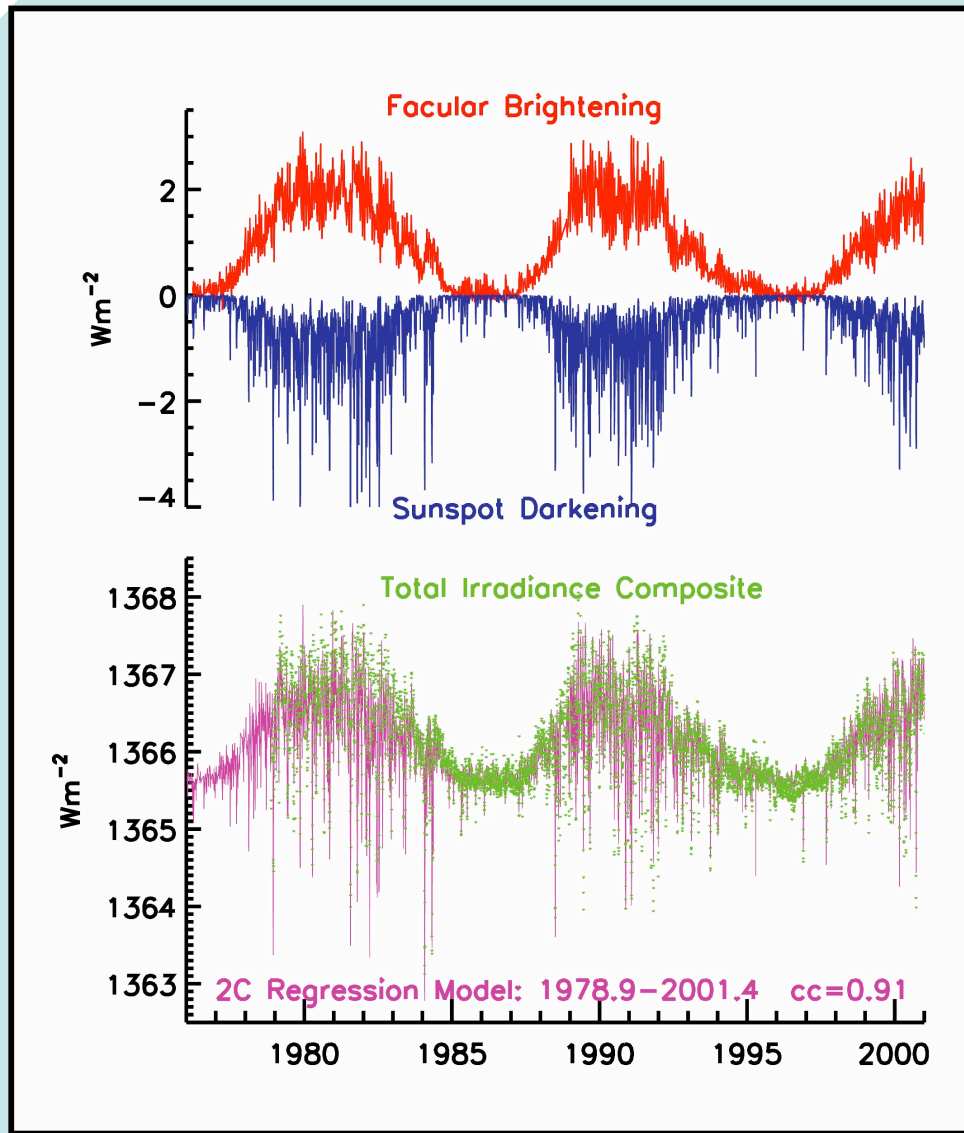
TSI Flare Observations Measure Total Flare Energy



TSI Record



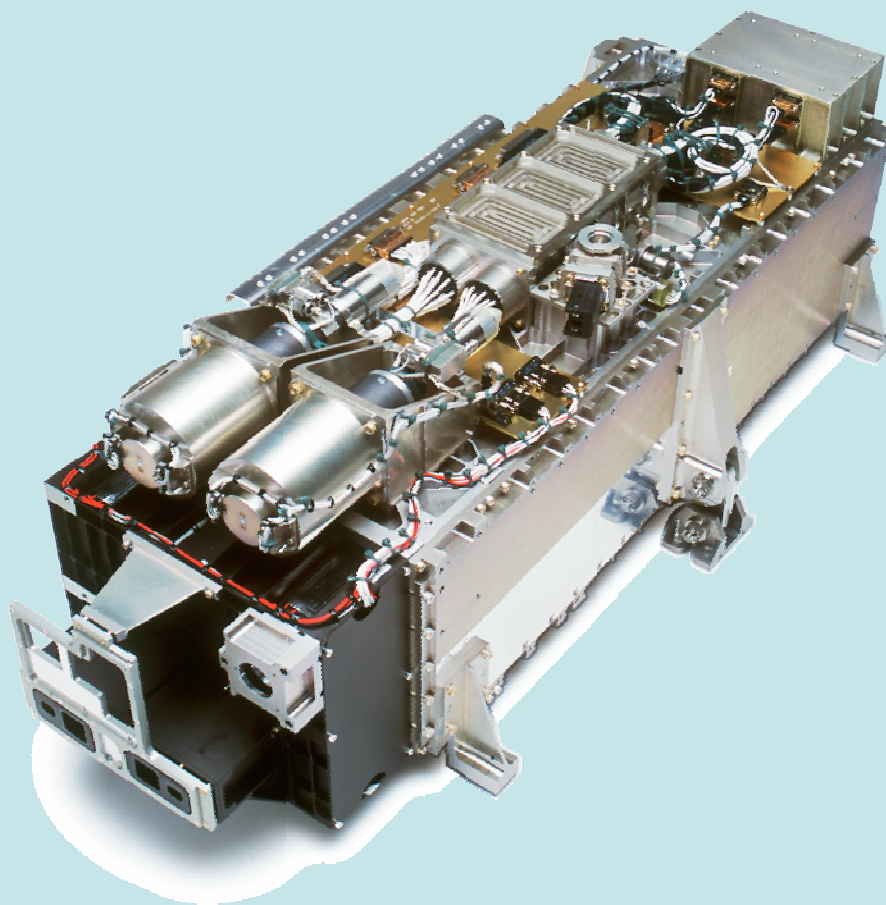
Model of TSI



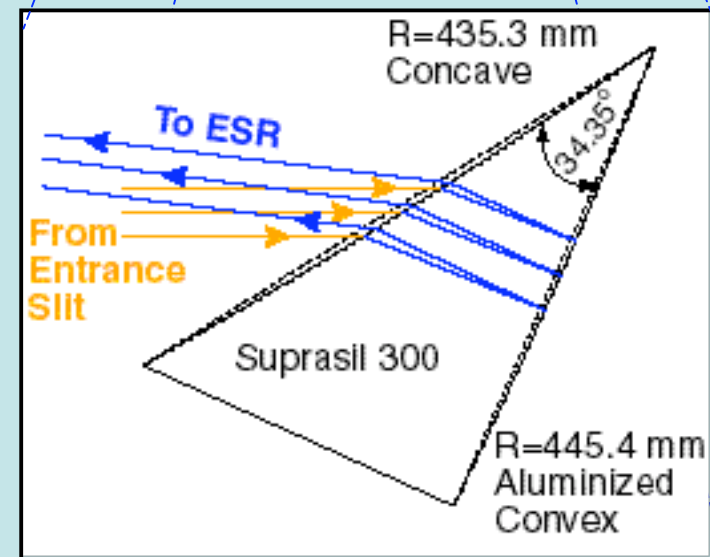
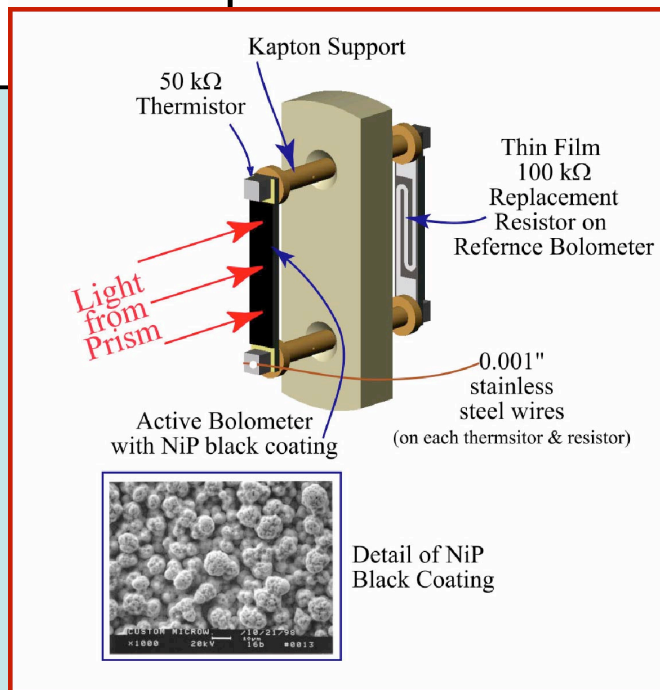
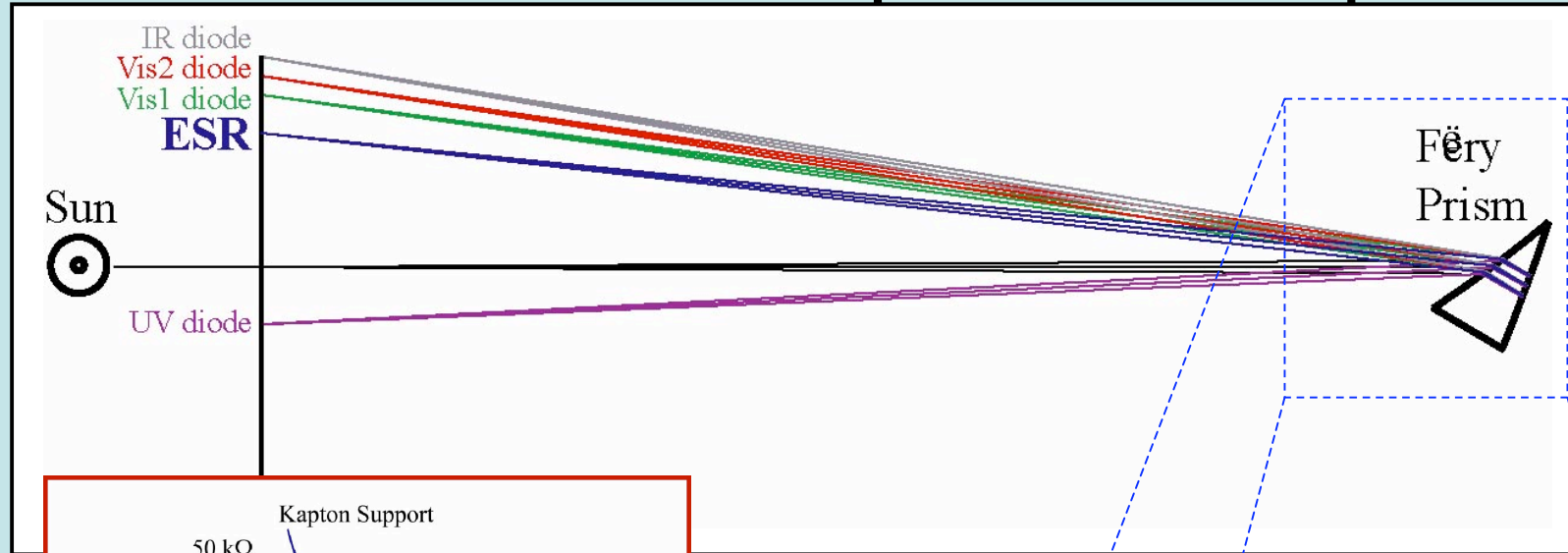
Solar variability on all temporal and spatial scales is intimately connected with variations of the solar magnetic field

Spectral Irradiance Monitor — SIM

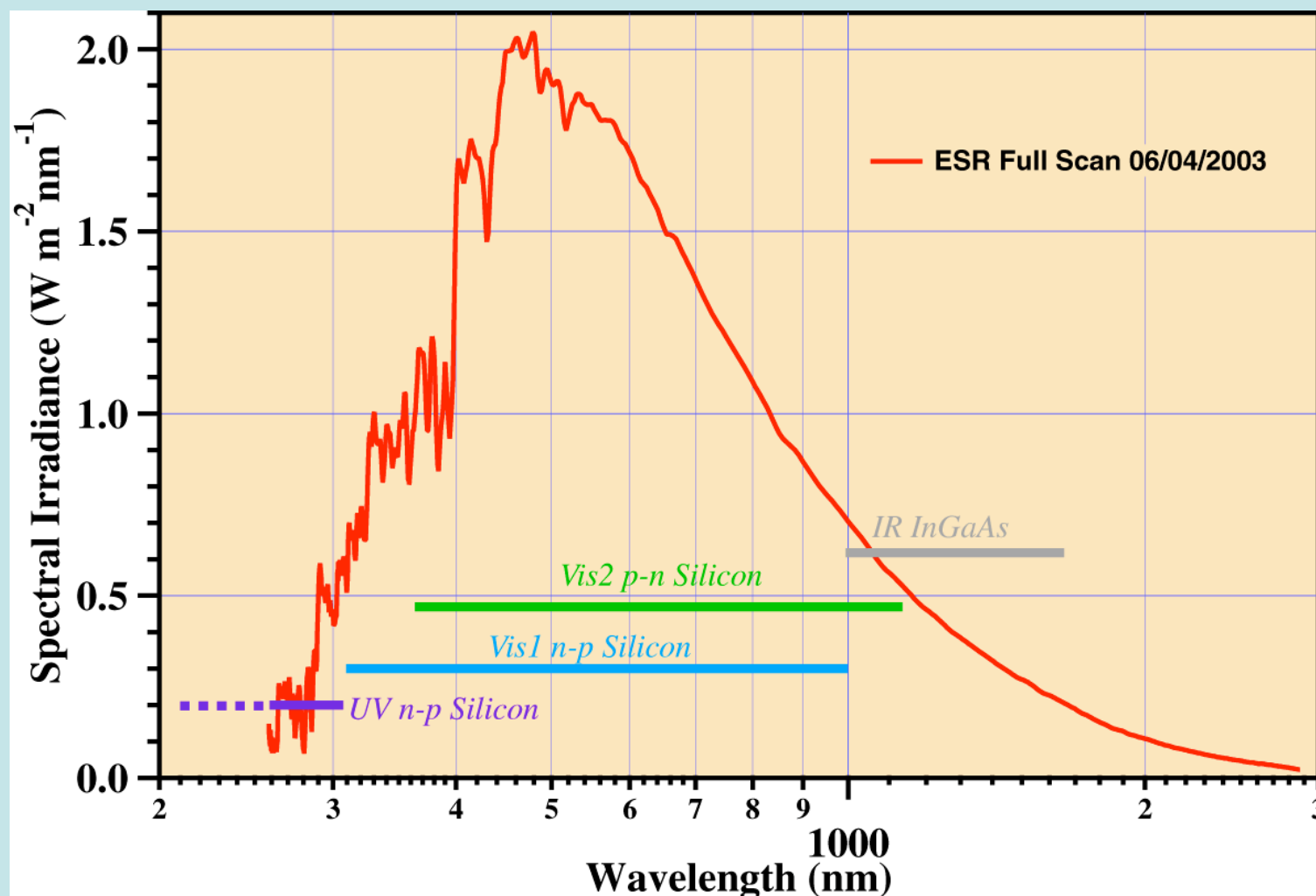
- **Instrument Type:** Dual Féry Prism Spectrometer
- **Wavelength Range:** 200-3000 nm
- **Wavelength Resolution:** 0.25-33 nm
- **Optics:** Suprasil 300 prism
- **Detectors:** ESR, 5 diodes
- **Absolute Accuracy:** 300 ppm
- **Relative Stability:** 100 ppm/year
- **Field of View:** $1.5^\circ \times 3.5^\circ$
- **Mass:** 22 kg
- **Orbit Average Power:** 25.3 W



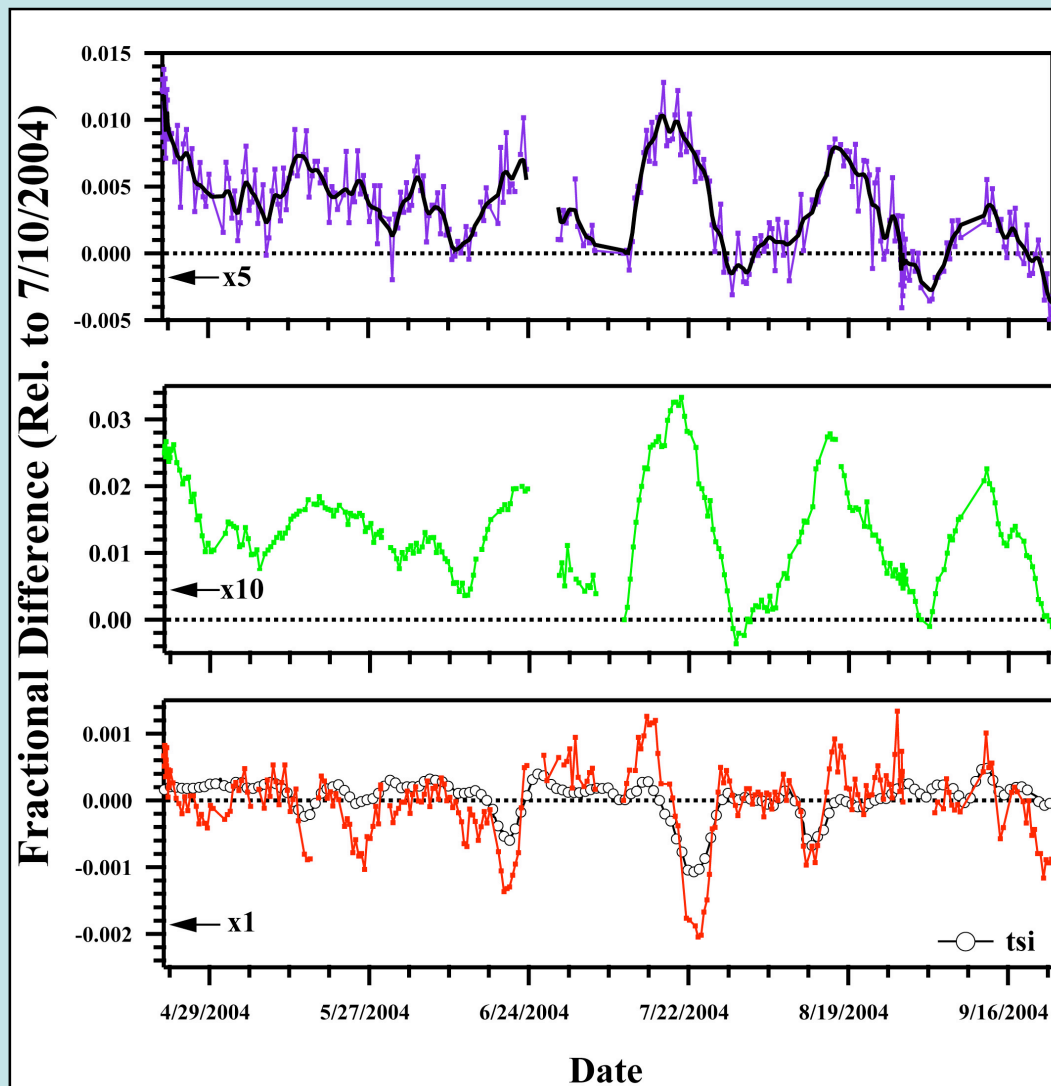
SIM Optical Concept



SIM ESR Irradiance Spectrum



Solar Variability in the Ultraviolet



250 nm: UV Pseudo-Continuum

- Formed from continuum flux from the top of the photosphere and densely spaced spectral lines in the lower chromosphere.
- Continuum contribution decreases with sunspot blocking, lines increase intensity due to presence of plage.
- Chromospheric component tends to dominate.

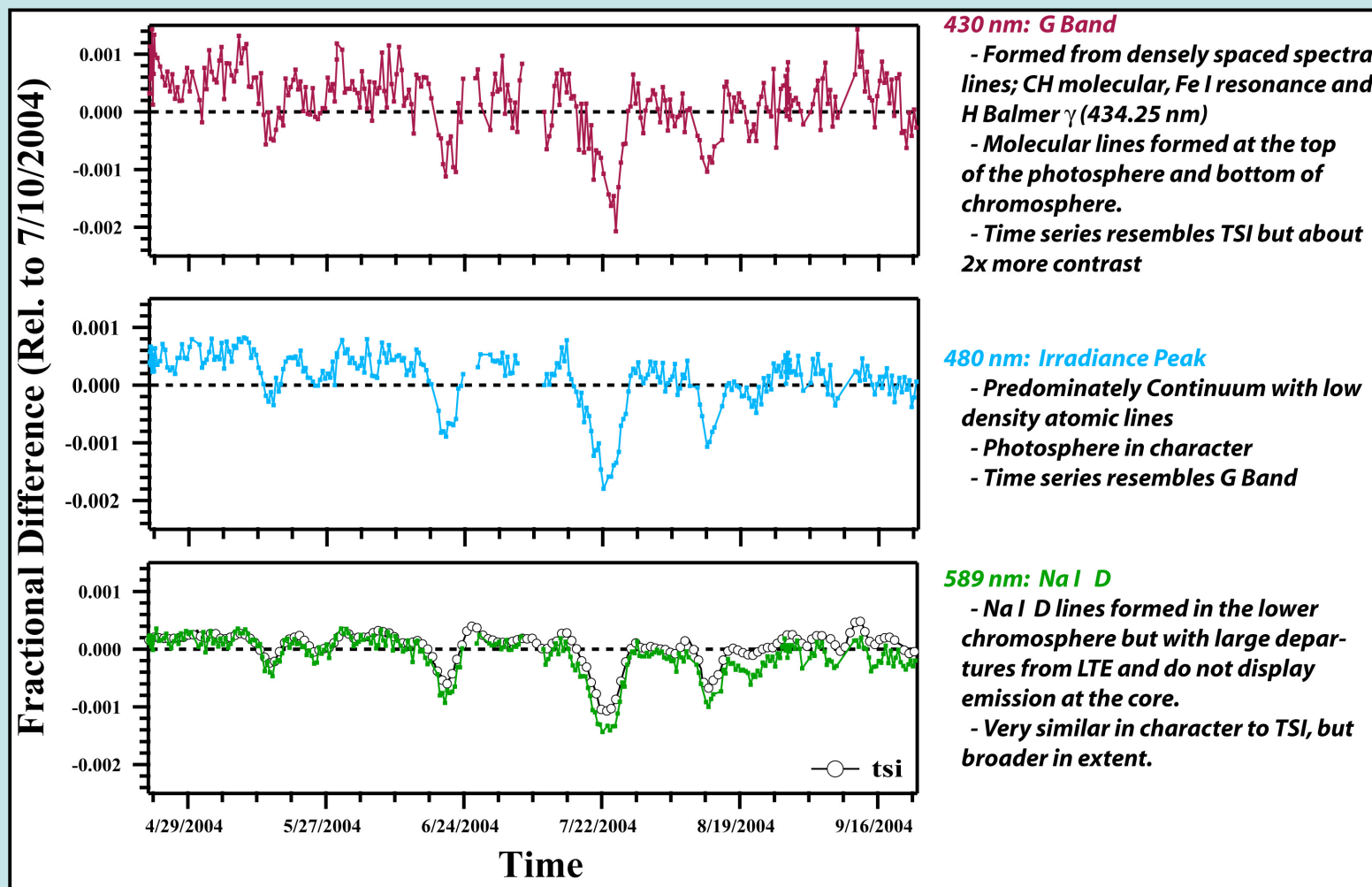
280 nm: Mg II

- Resolution 1.1 nm, so contains pseudo-continuum & the cores of the Mg II lines.
- 280 nm peaks when the plage areas are the largest.
- Flux is affected by the presence of active network structures.

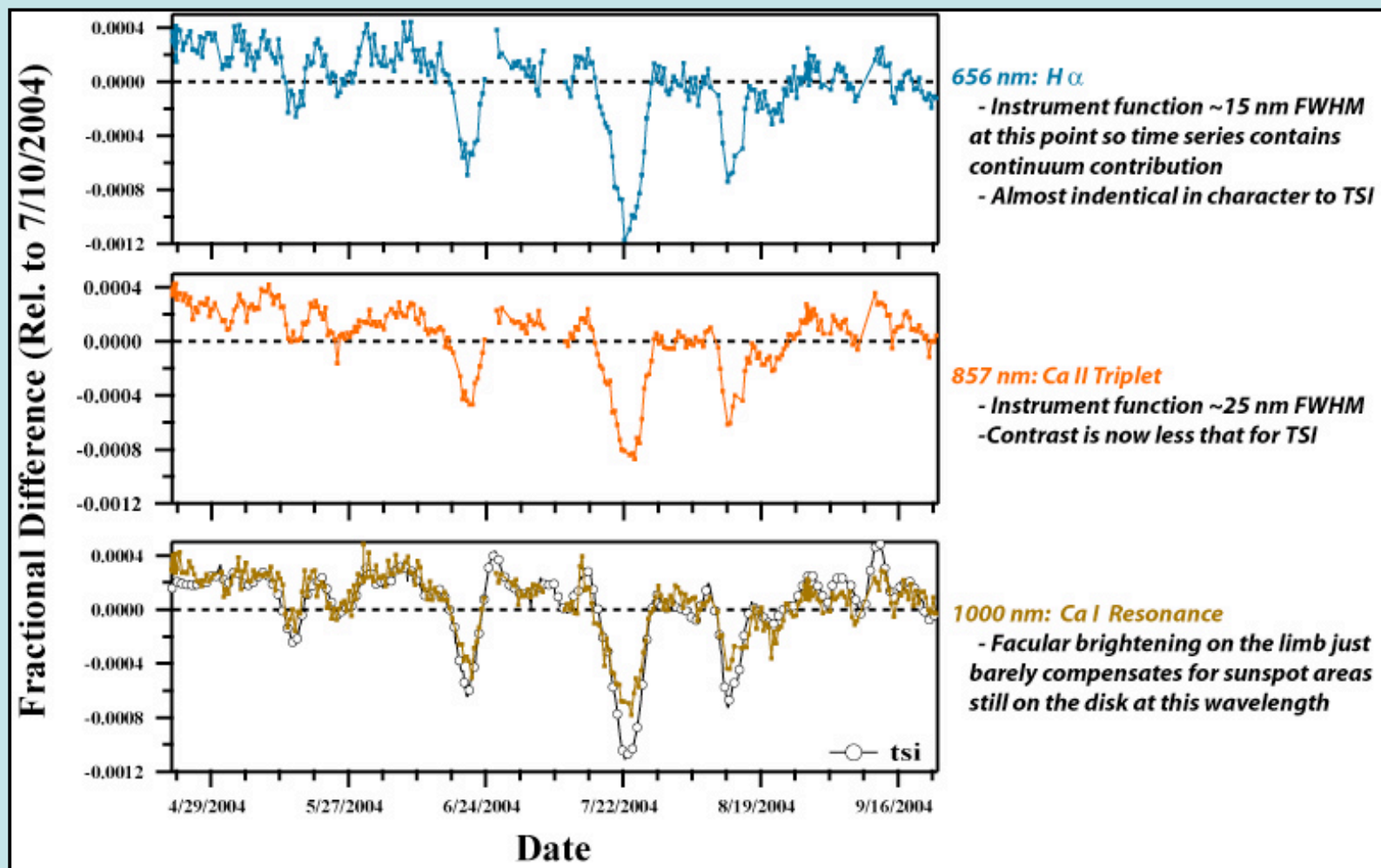
304 nm: Near-UV Pseudo-Continuum

- Continuum formed in deeper layers of the photosphere with less densely spaced lines than at 250 nm.
- Time series resembles TSI and is more photospheric in nature than chromospheric.
- A factor of ~2x contrast enhancement compared to TSI

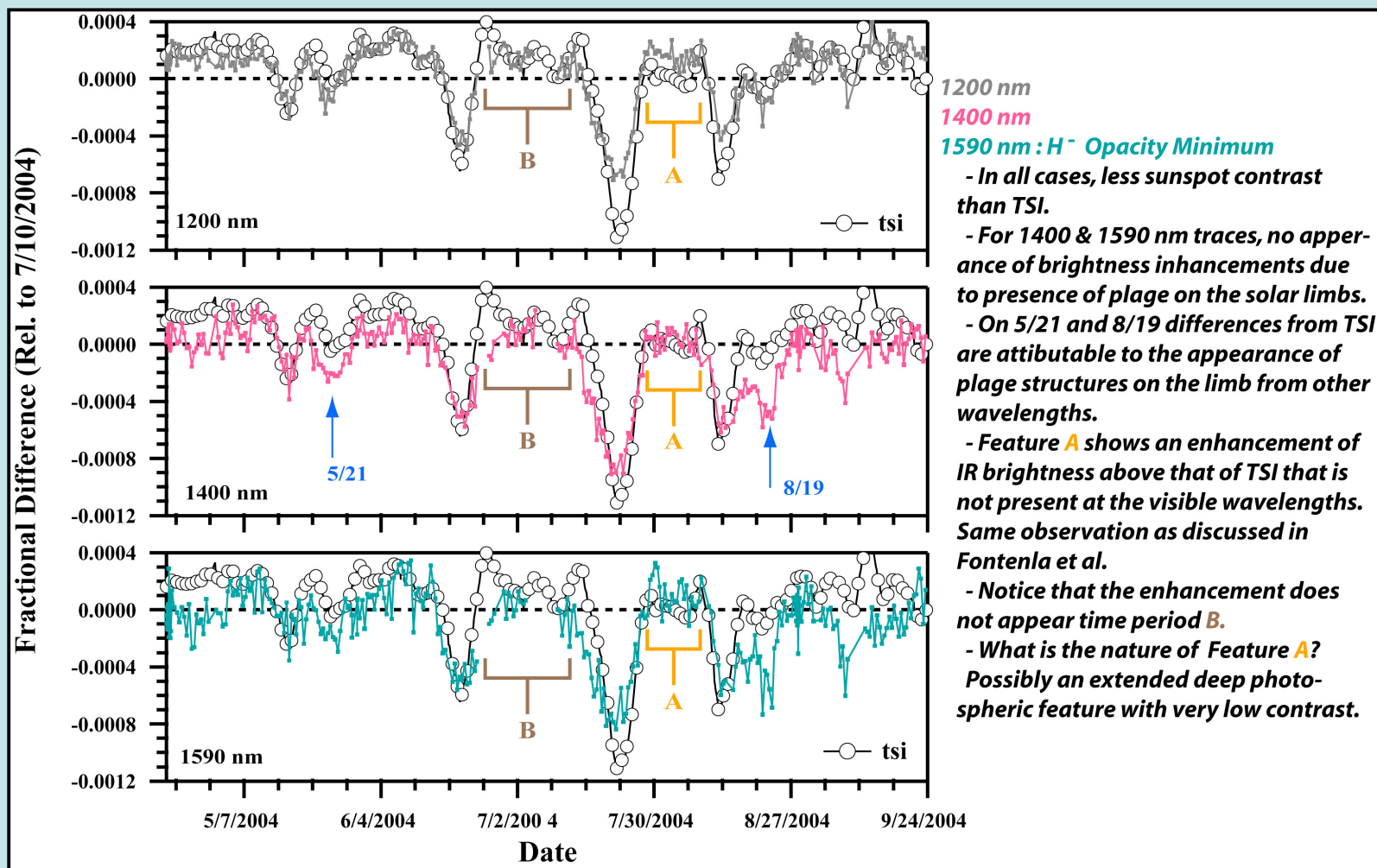
Solar Variability in the Visible – Short Wavelengths



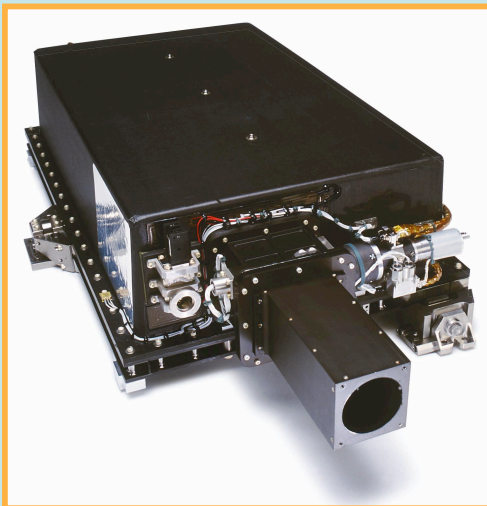
Solar Variability in the Visible – Long Wavelengths



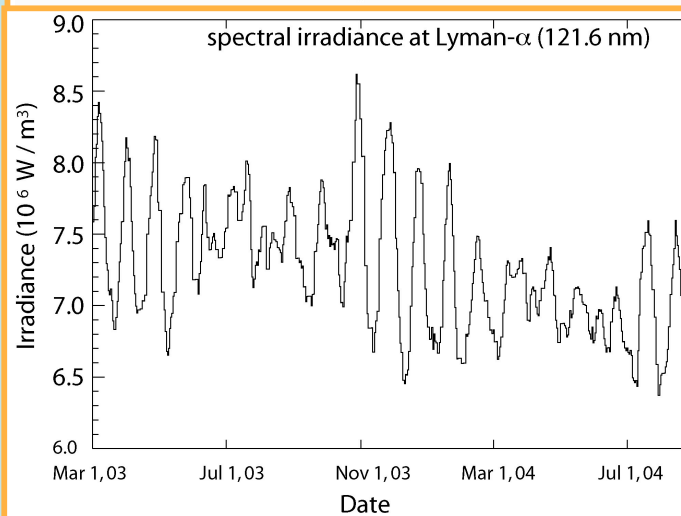
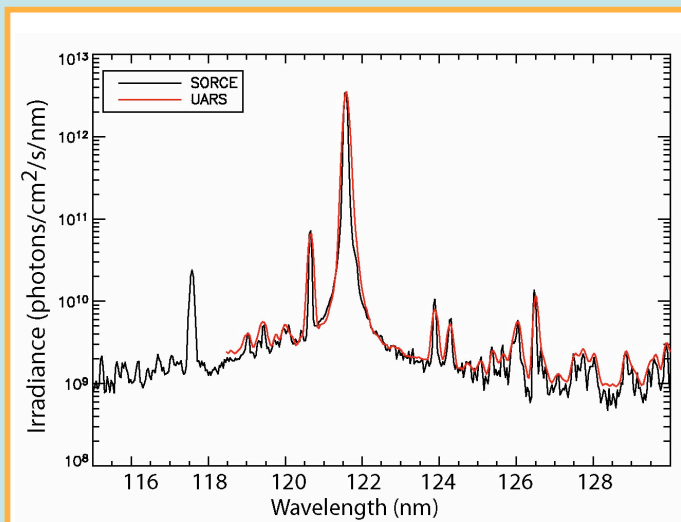
Solar Variability in the Infrared



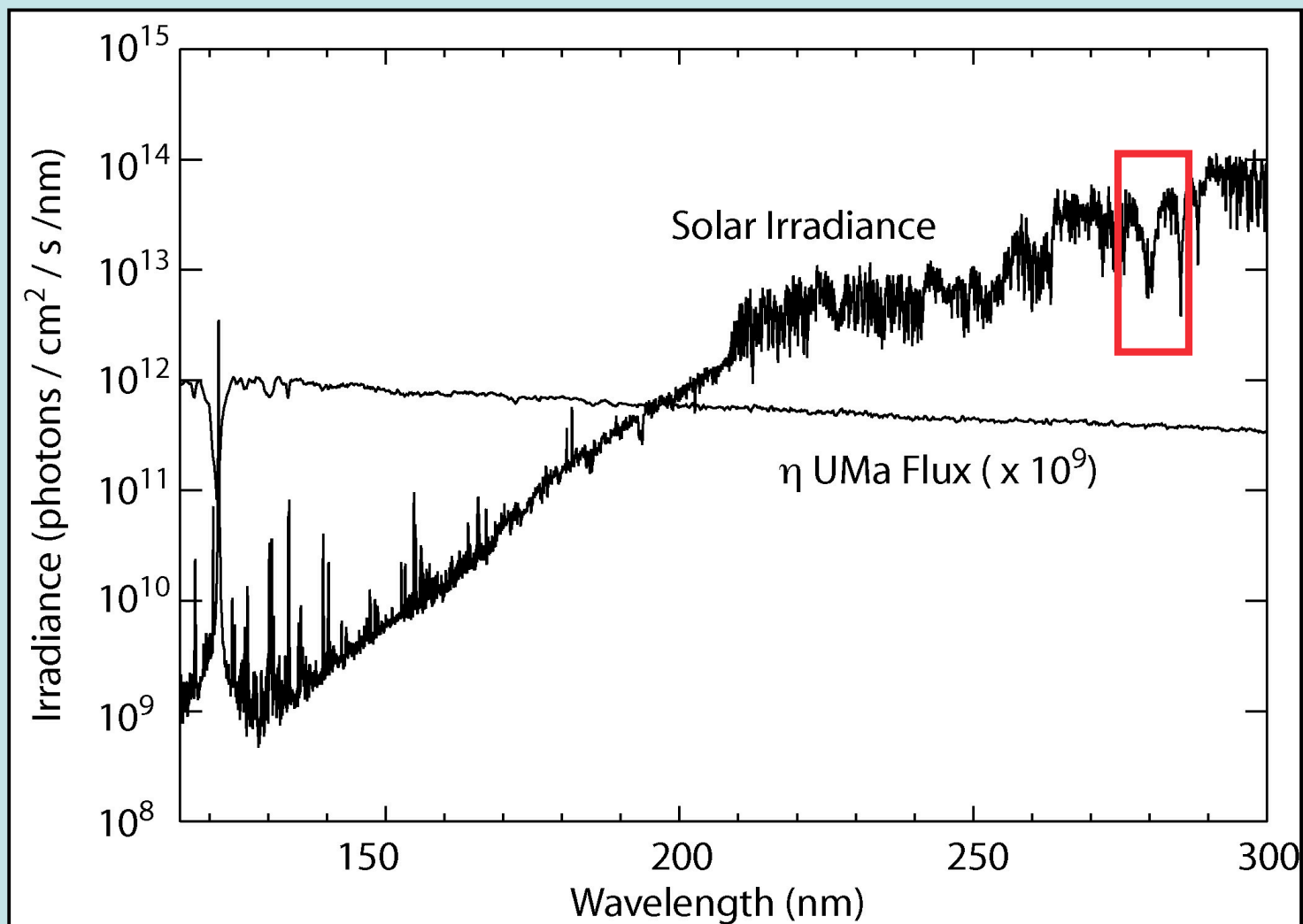
SORCE SOLSTICE



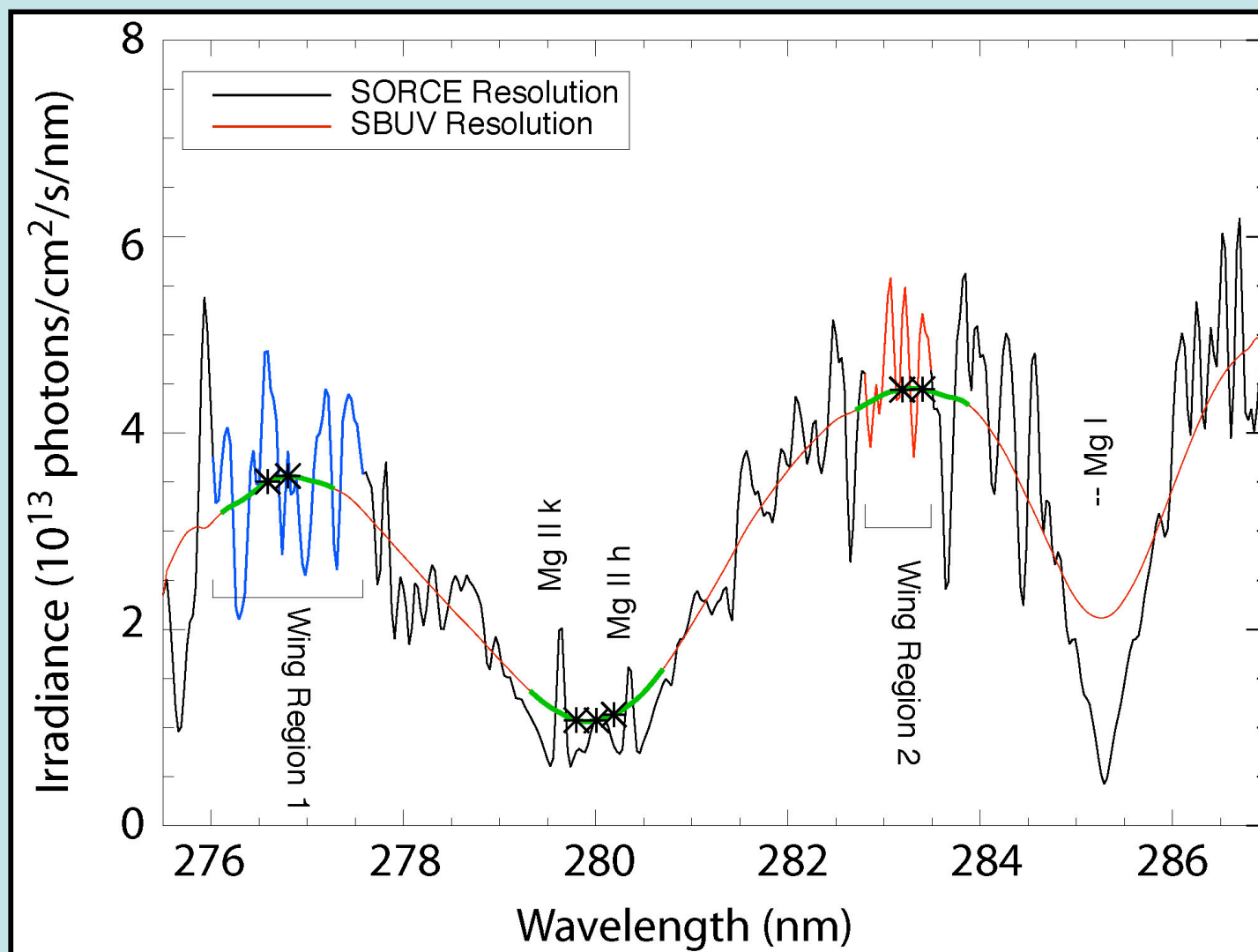
SORCE SOLSTICE continues the UARS data base. There are improvements in all aspects — stellar calibration, spectral resolution, and overall instrument performance.



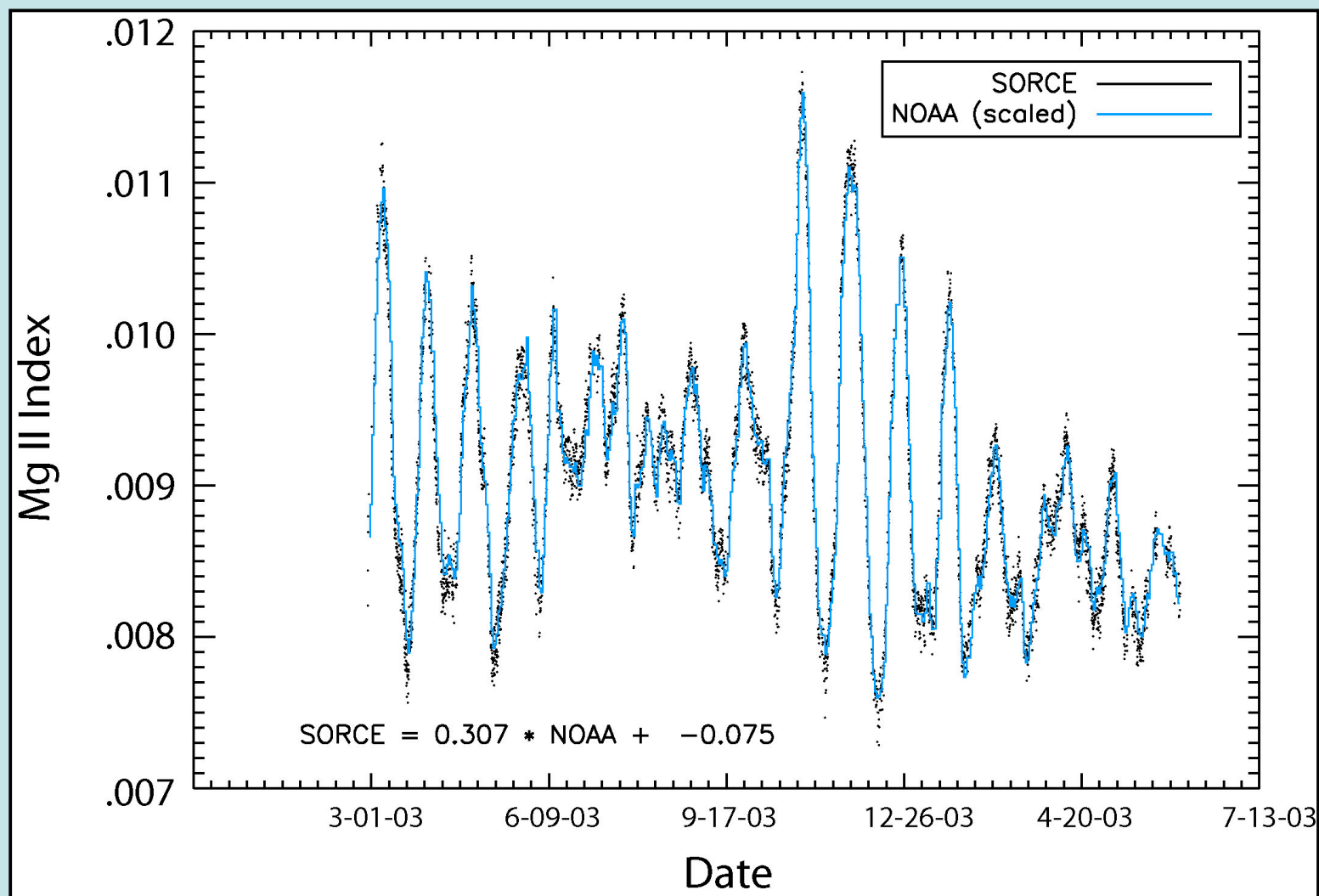
Solar Stellar Comparison



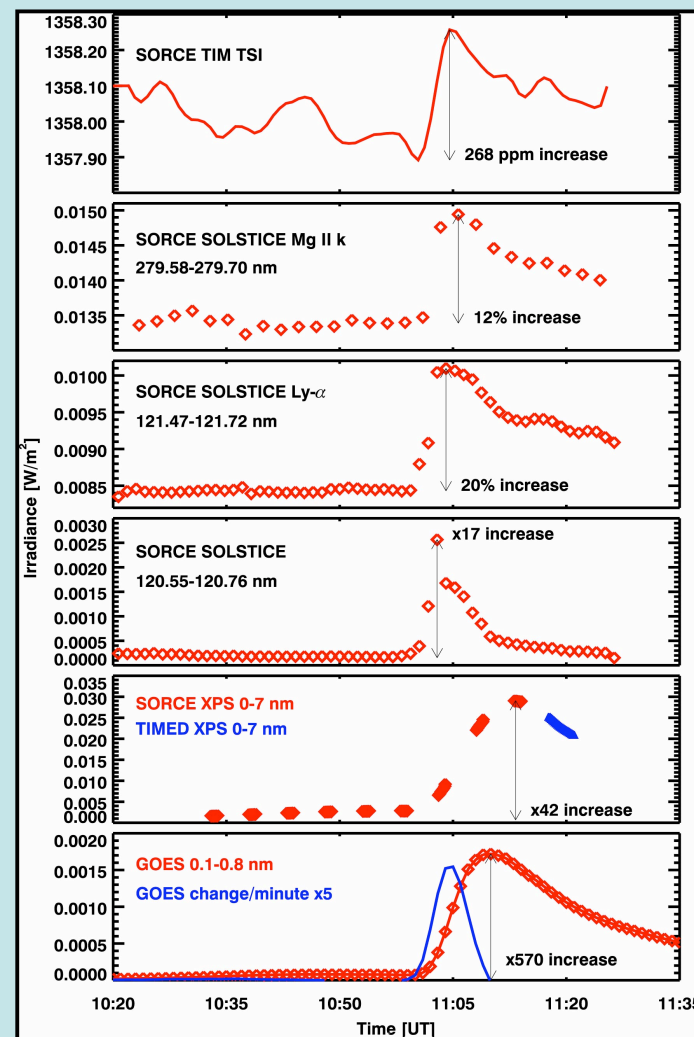
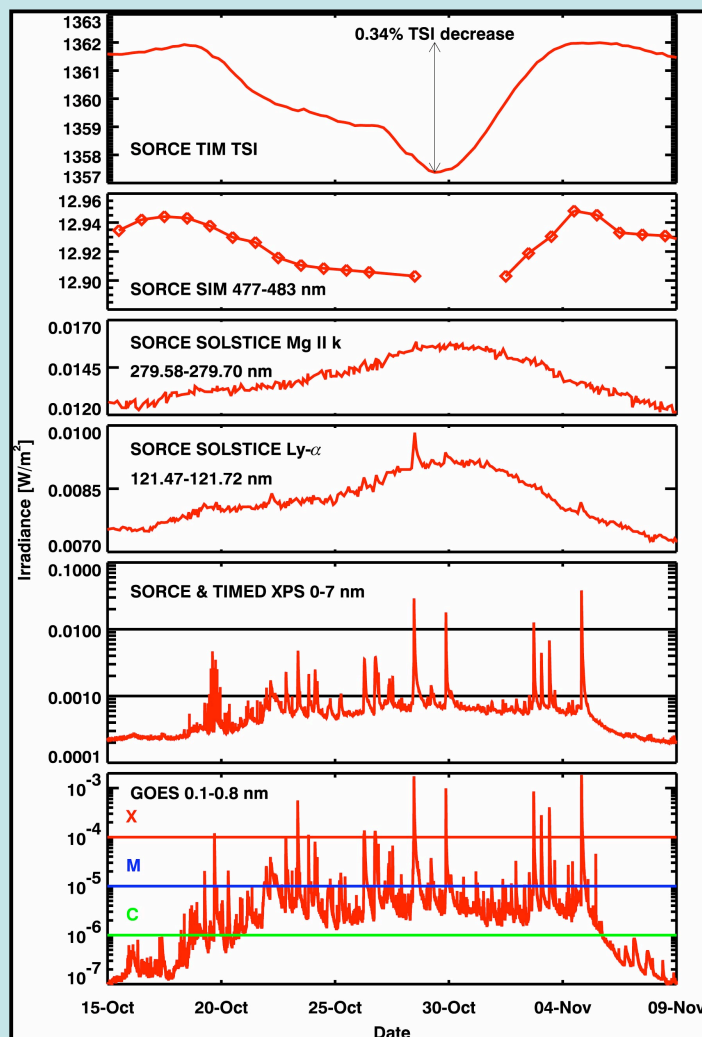
Magnesium II Index



Mg II Time Series



Light Curves of the October Activity and X17 Flare



SORCE



GLORY 12/06

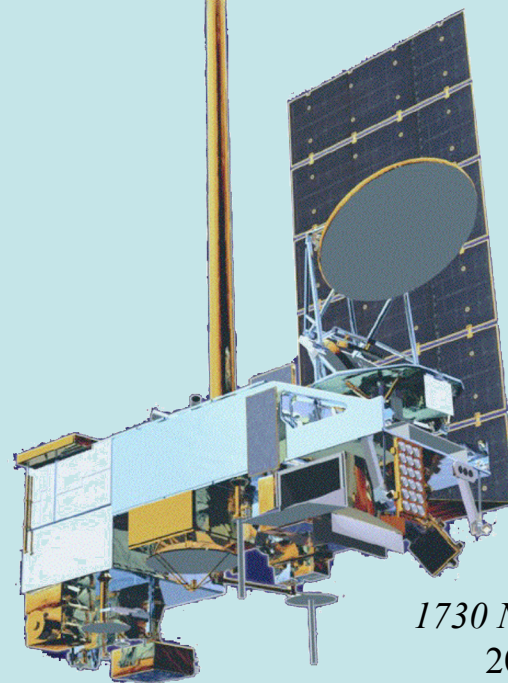
Follow-On to *SORCE* (after 2008)

2007 to 2011

NASA plans a Solar Irradiance Gap Filler (SIGF) that will be partially accomplished by placing a LASP TIM on the GSFC GLORY Mission. This will continue the long-term data record of TSI, but will not continue the spectral measurements of *SORCE*. There are no current plans by NASA to continue the UV ($\lambda < 200$ nm) irradiance observations of SME, UARS, TIMED, and *SORCE*.

2013 to 2020 +++++

NOAA/DOD/NASA will conduct the NPOESS (National Polar Orbiting Operational Environmental Satellite System) from 2010 onward. The payload will include the TSIS (Total and Spectral Irradiance Sensor) which includes a TIM and SIM instrument and a pointing platform. LASP is under contract with NGST to provide TSIS for a series of NPOESS spacecraft. There are no plans for the UV spectral irradiance to be provided on the future missions.



1730 NPOESS
2013

TIM May Be Flying on *Glory*?

